Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 93 (2013) 371 – 375
Procedia
Social and Behavioral Sciences

3rd World Conference on Learning, Teaching and Educational Leadership WCLTA-2012

Proficiency attained at the end of practice best predicts retention performance: Support for a competency-based approach to procedural skills training

Catharine M Walsh [a,b,c] *, Eric Hagemann [a], Adam Dubrowski [a,b,c], Heather Carnahan [a,c]

[a]*The Wilson Centre for Research in Education, University of Toronto, Toronto, Canada*
[b]*Hospital for Sick Chidren, Toronto, Canada*
[c]*Centre for Ambulatory Care Education, Women's College Hospital, Toronto, Canada*

Abstract

The efficacy of competency-based versus experience- oriented training of procedural skills for health professional trainees is unclear. This study examined whether the performance level attained at the end of practice (i.e., competency criteria) or the amount of practice best predicts retention of a procedural skill. Forty two trainees learned to perform a surgical knot using video-based instruction. There were 3 groups, each of which practiced until they reached a predefined criterion time to tie the knot (10, 15, or 20 seconds). Participants returned one week later for a timed retention test. Multiple regression analysis determined whether the number of practice trials, total practice time, or criterion reached at the end of practice was most predictive of the time taken to perform the skill during retention. Multiple regression analysis showed that the only significant predictor of performance at retention was the criterion reached at the end of practice ($p < 0.05$). Number of practice trials was not a significant predictor of retention performance ($p > 0.05$). The results support the notion that competency-based training results in better learning as compared with an experience-oriented approach.

Keywords: Competency based; Health professions education; Simulation; Training; Procedural skills.

1. Introduction

Learning of procedural skills is an important component of developing clinical competence for health professional trainees. Traditionally, the acquisition of procedural skills has followed an experienced-based paradigm, in which the trainee is required to perform a certain number of cases, or hours of practice, for any particular skill in order to satisfy their training requirements. This approach has been criticized for producing clinicians with variable skill levels, as the repetition or time allotment may not be sufficient to ensure slower learners have mastered the skill, while at the same time, it may be too much practice for faster learners (Gallagher et al., 2005). One alternative that has emerged in the literature is replacing the experienced-based model with a competency-based training paradigm, where trainees are required to achieve certain proficiency criterion, rather than an arbitrary amount of time or repetitions, in order to advance through their training (Aggarwal & Darzi, 2006; Debas et al., 2005; Gallagher et al., 2005). This pedagogical approach allows educators to tailor training to a

* Corresponding Author: Catharine M Walsh. Tel:+1-416-813-7500
E-mail address: catharine.walsh@mail.utoronto.ca

doi:10.1016/j.sbspro.2013.09.205

learner's individual characteristics such as innate ability, motivation and previous experience. In addition, use of a competency-based training paradigm may allow learners to achieve maximal benefit while optimizing training duration. Among the efficiencies this approach would achieve are potential economic savings, shorter training times and increased patient safety.

Early work in this area has been promising, as it has shown that incorporation of a competency-based approach into laparoscopic skills training curricula results in good acquisition, transfer and retention of skills (Korndorff et al., 2005; Seymour et al., 2002; Sonnadara et al., 2012; Stefanidis et al., 2005; Stefanidis, Acker, & Heniford, 2008). However, these studies have examined a single cohort training to a specified competency level; varying competency levels were not compared. Hence, it is difficult to assess the impact one's end of practice performance has on skill retention, as compared with duration and amount of practice. Therefore, this study aimed to examine whether the performance level attained at the end of practice (i.e., proficiency criteria), the duration of training, or the amount of practice best predicts retention of a procedural skill.

2. Methods

2.1. Participants

Forty-two undergraduate students who had no prior training in the skill of interest within the clinical or simulated environment were recruited to participate in this study. Approval was granted by the local university research ethics board, and informed consent was obtained from all participants.

2.2. Procedure

A written questionnaire was administered to all participants at baseline to collect demographic and background information including sex, age, and hand dominance. All participants then viewed a five-minute training video detailing how to correctly perform a single-handed double-square knot which provided both verbal instruction and expert demonstration of the skill (Jowett, LeBlanc, Xeroulis, MacRae, & Dubrowski, 2007)

According to a computer-generated randomization list, participants were then randomly assigned to one of three practice conditions, each with their own predefined criterion time to complete the surgical knot: 10, 15 or 20 seconds. Criteria were based on the average performance times on this task of practicing surgeons, surgical residents and undergraduate medical students respectively (Jowett et al., 2007). Subsequently, all participants took part in one training session during which they were required to practice the single-handed double-square knot on a bench-model, which consisted of a string (30cm long, 0.3cm thick) and a 2cm diameter wooden dowel, which was suspended horizontally in front of the participant by 2 metal clamps (Jowett et al., 2007).

During the practice session, participants were instructed to carry out the skill as many times as necessary until the knot could be tied within their predefined criterion time (10, 15, or 20 seconds). The task began with the string wrapped half-way around the dowel, and the participant grasping both ends of the strings. The criterion was reached when the participant correctly completed the knot. Participants were encouraged to attempt the skill until completion on all trials, rather than trying to complete only one part of the skill at a time. If on any of the practice trials the knot could not be completed, the subsequent trial was repeated from the beginning position. That is, participants could not start a trial with the knot partially completed. After each trial, participants had the option of reviewing the video or completing another practice trial; however, they were not allowed to practice the procedure while the video was playing. All performance information regarding correct procedural sequence and assessment of knot quality was provided by the video alone. The examiner provided participants with their completion time after each trial; however, no additional extrinsic feedback was offered. Once a participant completed one knot within their criterion time, their practice session ended.

After a one-week interval, all participants returned for a timed retention test consisting of one trial of the knot-tying skill. No video instruction, feedback or practice trials were allowed during the retention interval or testing.

2.3. Performance measures

2.3.1. Execution time

During the retention test, time from first movement of the string to task completion was quantified.

2.3.2. Total practice time

During the practice session, each attempt at tying the knot, whether successful or not, was counted as one trial. Time from first movement of the string to trial completion was measured for all trials. Practice was terminated when a participant was able to complete the task within their predefined criterion time. Total practice time was measured by summing the completion times on all complete practice trials, as well as the time spent practicing on failed attempts.

2.4. Statistical analysis

The number of trials to reach criterion and execution time at retention were analyzed in separate three group ('Criterion of 10 seconds', 'Criterion of 15 seconds', and 'Criterion of 20 seconds') between subject analyses of variance (ANOVAs). ANOVA differences significant at $p < 0.05$ were further analyzed using Tukey honestly significant difference tests. Multiple step-wise regression analysis was used to determine whether the number of practice trials, total practice time, or criterion reached at the end of practice was most predictive of the time taken to perform the skill during retention.

3. Results

Participants included 42 undergraduate students (28 female and 14 male; mean age = 20.6 years (range 18-23 years); 39 right-handed and 3 left-handed). Average age, gender distribution, and hand dominance were similar for participants in the 10 (n = 14), 15 (n = 14) and 20 second (n = 14) criterion time groups ($p > 0.05$).

Analysis of the number of trials required to reach criterion showed a significant main effect of group ('Criterion of 10 seconds', 'Criterion of 15 seconds', and 'Criterion of 20 seconds') ($F_{2,39} = 9.85$, $p < 0.05$). Tukey post hoc analysis of the main effect of group indicated that participants in the group with a 'Criterion of 10 seconds' performed on average significantly more trials (mean = 23.21) in order to reach their criterion time as compared with trainees in the 'Criterion of 15 seconds' (mean = 12.57) and 'Criterion 20 seconds' (mean = 10) groups ($p < 0.05$) which did not differ significantly from one another.

Analysis of execution time at retention showed a significant main effect of group ('Criterion of 10 seconds', 'Criterion of 15 seconds', and 'Criterion of 20 seconds') ($F_{2,37} = 5.37$, $p < 0.05$). Tukey post hoc analysis of the main effect of group indicated that those in the group with a 'Criterion of 10 seconds' were able to complete the knot tying task significantly faster (mean = 14.79 seconds) during retention testing as compared with trainees in the 'Criterion of 15 seconds' (mean = 24.14 seconds) and 'Criterion 20 seconds' (mean = 23.67 seconds) groups ($p < 0.05$) which did not differ significantly from one another.

The number of practice trials was correlated with total practice time (r = 0.82, $p < 0.05$); therefore, time was withdrawn as a predictor from subsequent analysis. Multiple regression analysis showed that the only significant predictor of performance at retention was the criterion reached at the end of practice ($p < 0.05$). Number of practice trials was not a significant predictor of retention performance ($p > 0.05$).

4. Discussion

Simulation-based procedural skills training curricula allow trainees to develop some competency in basic psychomotor skills in a risk free environment, prior to performance on patients within the clinical setting. Traditionally these curricula have been grounded on an experience-based educational paradigm that, as we highlighted above, ignores individual variability with respect to skill acquisition. The fundamental abilities' of trainees varies widely making it hard to establish experience-based criterion (i.e., number of practice trials or practice time) that would ensure appropriate performance of skills prior to training within the clinical setting (Gallagher et al., 2005). The competency-based model of training, in which trainees only advance once they have achieved predefined proficiency criterion levels, is increasingly being integrated into health professions education as a means of addressing this limitation.

Competency-based simulator curricula have been shown to result in durable improvement in procedural skills (Sonnadara et al., 2012; Stefanidis et al, 2008). Furthermore, skills learned within the simulated setting have been shown to lead to sustained improved performance within the clinical setting (Ahlberg et al., 2007; Stefanidis et al., 2005). Competency-based training of basic procedural skills has also been shown to decrease overall training time with no impact on training outcome, transferability or retention of skills (Brinkman, Buzink, Alevizos, de Hingh, & Jakimowica, 2012). In addition to improved performance, Stefanidis, Acker, and Greene (2010) showed that another benefit to the incorporation of proficiency criterion into training is improved trainee motivation. This may serve to promote adequate attendance of trainees in order to help ensure engagement in deliberate practice, one of the biggest challenges of simulation-based education. While studies to date clearly indicate that there is benefit to the integration of performance goals into training, there has been little work to directly compare the influence of experience- and competency-based educational paradigms on learning. Data from the current study showed that the only significant predictor of performance at retention was the criterion reached at the end of practice: findings which support the notion that competency-based training results in better learning as compared with an experience-oriented approach. The number of procedures and practice time, on the other hand, were not significant predictors of retention test performance.

One potential reason for these findings is that competency-based simulator training allows total practice time and the number of practice trials to vary among learners, while keeping the level of mastery achieved constant (Willis et al., 2012). This allows trainees to receive a training regimen tailored to their individual capabilities. Another potential reason for the learning benefit associated with competency-based training is that this type of training may help to more effectively engage a learner in deliberate practice: a key to the development of clinical competence. Deliberate practice consists of activities purposely designed to improve performance. According to Ericson, Krampe and Clemens (1993), deliberate practice requires that a trainee is motivated to improve their performance during a repetitive practice session that takes into account a trainee's pre-existing skill set and is designed specifically to improve performance by setting appropriate goals, identifying areas of weakness, and working on those areas while engaging the learner in self-observation and self-reflection. The competency-based training model fulfills each of these characteristics. As mentioned previously, incorporation of proficiency criteria into simulation curricula has been shown to enhance trainees' motivation (Stefanidis et al., 2010) and likely helps to provide the impetus necessary to engage trainees in the skill acquisition process more effectively than an experience-based model of training where trainees are required to practice for a predefined time or perform an arbitrary number of practice trials.

While the current study examined basic procedural skills acquisition for health professions trainees, it did not formally assess the effects of competency-based training on the retention of more complex tasks or other important clinical skills such as history taking, physical examination, or clinical decision making. One has to be cautious in extrapolating the results of this study to other skills and populations as the sample size was relatively small and learning is believed to be task-specific. In addition, the current study did not assess whether improved performance within the simulated setting transfers to the clinical setting. On the basis of the study findings one can hypothesize that the performance level attained at the end of practice (i.e., competency criteria) best predicts performance in the clinical environment, as superior performance on retention testing suggests greater generalizability of learning (Schmidt, 1975). Finally, the proficiency criterion utilized in the current study was based on execution speed and did not incorporate other measures such as expert-based ratings of performance. The criterion times were, however, based upon average performance times, on the skill of interest, of practicing surgeons, surgical residents and undergraduate medical students (Jowett et al., 2007). Further work needs to be done to determine how best to set proficiency criterion.

There has been a push within the field of health professions education for educators to think more critically about new approaches to procedural skills training (Harden, Grant, & Hart, 2005). It is important for educators to move from opinion-based to evidence-based education, where new instructional methods and curricula are integrated into training based on sound theoretical principles and investigation. Our results support the notion that competency-based training results in better learning of basic procedural skills as compared with an experience-oriented approach, providing evidence for the incorporation of competency-based training into procedural skills curricula.

References

Ahlberg, G., Enochsson, L., Gallagher, A.G., Hedman, L., Hogman, C., McClusky, D.A. 3rd, … Arvidsson, D. (2007). Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies. *American Journal of Surgery*, *193*(6), 797-804.

Aggarwal, R., & Darzi, A. (2006). Technical-skills training in the 21st century. *The New England Journal of Medicine, 355*(25), 2695-6.

Brinkman, W.M, Buzink, S.N., Alevizos, L., de Hingh, I.H., & Jakimowica, J.J. (2011) Criterion-based laparoscopic training reduces total training time. *Surgical Endoscopy*, *26*(4), 1095-101.

Debas, H. T., Bass, B. L., Brennan, M. F., Flynn, T. C., Folse, J. R., Freischlag, J. A.,… Zinner, M. J. (2005). American surgical association blue ribbon committee report on surgical education: 2004. *Annals of Surgery*, 241(1), 1-8.

Ericsson, K.A., Krampe, R.T., & Clemens Tesch-Romer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363-406.

Gallagher, A.G., Ritter, E.M., Champion, H., Higgins G., Fried, M.P., Moses, G., … Satava, R. M. (2005). Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Annals of Surgery*, *241*(2), 364-72.

Harden, R.M., Grant, J., Buckley, G. & Hart, I.R. (2000). Best Evidence Medical Education. *Advances in Health Sciences Education Theory and Practice*, *5*(1), 71-90.

Jowett, N., LeBlanc V., Xeroulis G., MacRae, H., & Dubrowski, A. (2007). Surgical skill acquisition with self-directed practice using computer-based video training. *The American Journal of Surgery*, *193*(2), 237–42.

Korndorffer, J.R. Jr, Dunne, J.B., Sierra, R., Stefanidis, D., Touchard, C.L., & Scott, D.J. (2005). Simulator training for laparoscopic suturing using performance goals translates to the operating room. *Journal of the American College of Surgeons*, *201*(1), 23–9.

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review*, *82*, 225–60.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K., & Satava, R. M. (2002). Virtual reality training improves operating room performance - results of a randomized, double-blinded study. *Annals of Surgery*, *236*(4), 458-63.

Sonnadara, R.R., Garbedian, S., Safir, O., Nousiainen, M., Alman, B., Ferguson, P.,… Reznick, R. (2012). Orthopaedic Boot Camp II: examining the retention rates of an intensive surgical skills course. *Surgery, 151*(6), 803-7.

Stefanidis, D., Acker, C.E., & Greene, F.L. (2010). Performance goals on simulators boost resident motivation and skills laboratory attendance. *Journal of Surgical Education*, *67*(2), 66-70.

Stefanidis D., Acker C., & Heniford, B.T. (2008). Proficiency-based laparoscopic simulator training leads to improved operating room skill that is resistant to decay. *Surgical Innovation*, *15*(1), 69-73.

Stefanidis, D., Korndorffer, J. R., Sierra, R., Touchard, C., Dunne, J. B., & Scott, D. J. (2005). Skill retention following proficiency-based laparoscopic simulator training. *Surgery, 138*(2), 165-70.

Willis, R.E., Richa, J., Oppeltz, R., Nguyen, P., Wagner, K., Van Sickle, K.R., & Dent, D. L. Comparing three pedagogical approaches to psychomotor skills acquisition. *American Journal of Surgery, 203*(1), 8-13.